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# Water-based Acrylic Polymer Incorporating Cellulose Nanocrystal for Coating of Food Packaging Films

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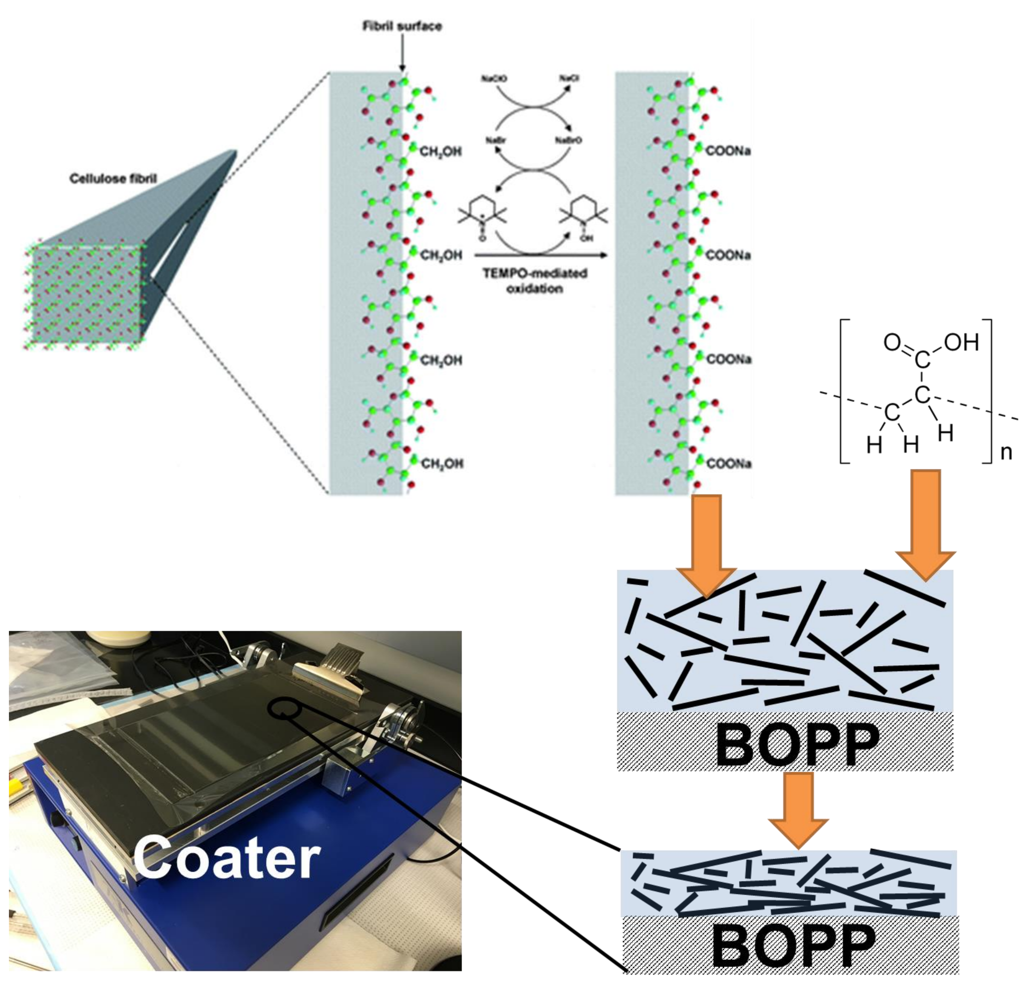
## Introduction

Production of biofuels from woody biomass yields a significant amount of cellulose as a byproduct that is biodegradable, non-toxic, and has strong gas barrier properties. The goal of the work is to reduce the waste in biofuel production by developing an application for the cellulose in food packaging coatings by production of a Water-based Acrylic Polymer that incorporates refined Cellulose particles as a replacement for petrol-based plastics. In order to be of use in this application the cellulose must be, biodegradable, stable in emulsion, and provide beneficial gas barrier qualities.

## Methods

- Nanocellulose undergoes a TEMPO aided oxidation to convert the hydroxyl functional groups to a carboxyl group. This is done to decrease particle size and to create a net charge on the surface of the nonpolar nanocellulose to improve its solubility in the emulsion.
- A water based acrylic polymer-nanocellulose emulsion is prepared using varying weights/chain lengths of nanocellulose and Joncryl 678 Acrylic Polymer (26wt% solid, with 6.3wt% ammonia).
- The Acrylic Polymer-Nanocellulose emulsion is then tested for its physical properties as well as mechanical tests with the emulsion coated onto Biaxially Oriented Polypropylene (BOPP) films.




## Research Approach for Packaging Applicability

- Tensile Strength Testing to determine Ultimate Tensile Strength of BOPP coated with the polymer emulsion.
- Viscometry of polymers at different weight percentages of nanocellulose.
- Transparency Testing of BOPP Films with and without coating of Acrylic-Nanocellulose emulsion.

## Results

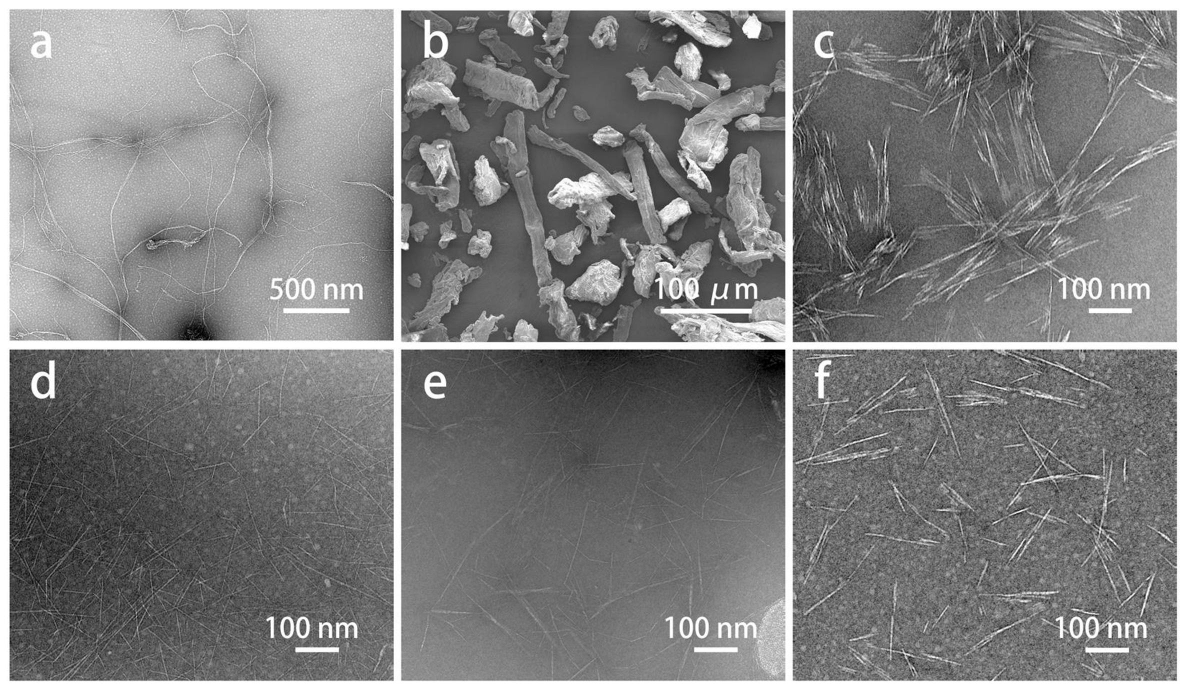



Figure 1
Structures of
a. Cellulose Nanofiber (CNF)
b. Microcrystaline cellulose (CMC)
c. Cellulose Nanocrystal (CNC)
d. TEMPO Oxidized CNF
e. TEMPO Oxidized CMC
f. TEMPO Oxidized CNC

Table 1
Nanocellulose Dimenstions

| Cellulose | Length | Width | Cellulose | Length | Width |
|---|---|---|---|---|---|
| CNF | >500 nm | ~20 nm | TEMPO-Oxidized CNF | 174 nm | 3.6 nm |
| CNC | 234 nm | 10 nm | TEMPO-Oxidized CNC | 149 nm | 6.5 nm |
| CMC | 74 µm | ~10 µm | TEMPO-Oxidized CMC | 108 nm | 5.9 nm |

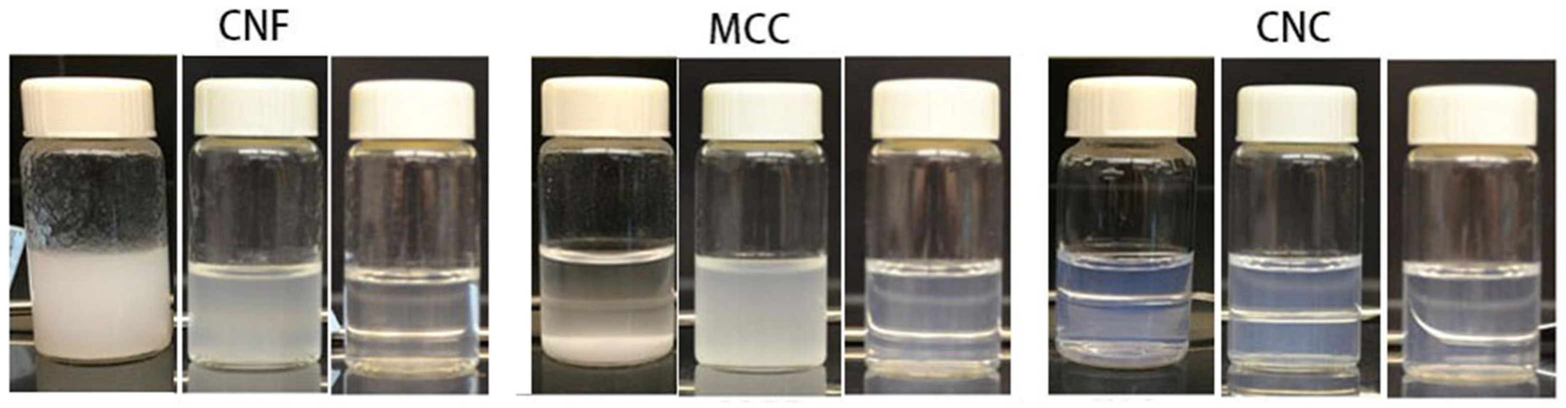



Figure 2
The transparency of raw nanocellulose, TEMPO oxidized cellulose, TEMPO oxidized cellulose with 10min Ultrasound (left to right).

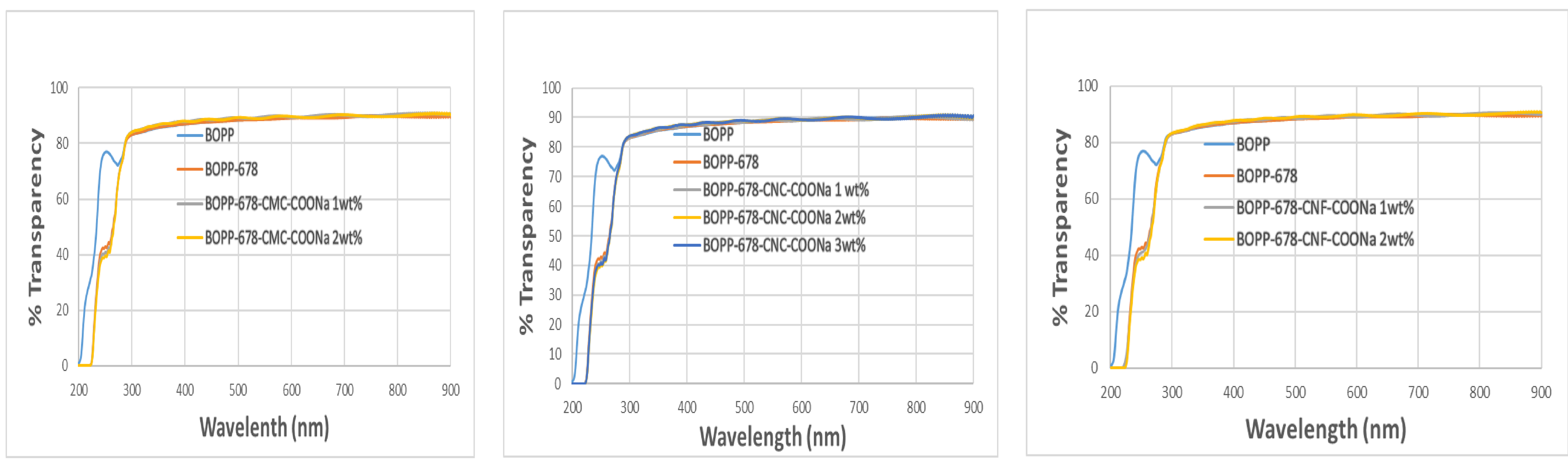



Figure 3
Transparency of BOPP-678 CMC-COONa, CNC-COONa, CNF-COONa

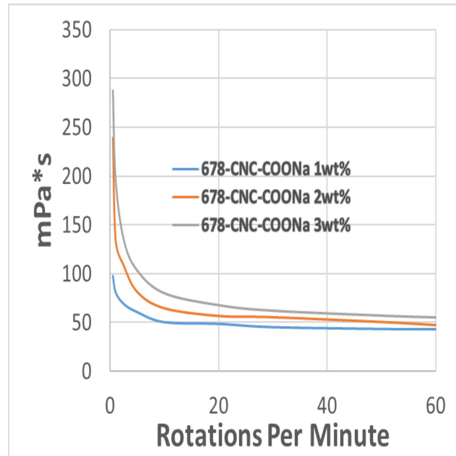



Figure 4
Viscosity of
678 CNC-COONa

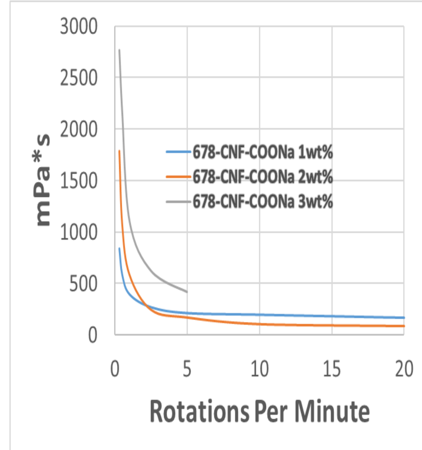



Figure 5
Viscosity of
678 CNF-COONa

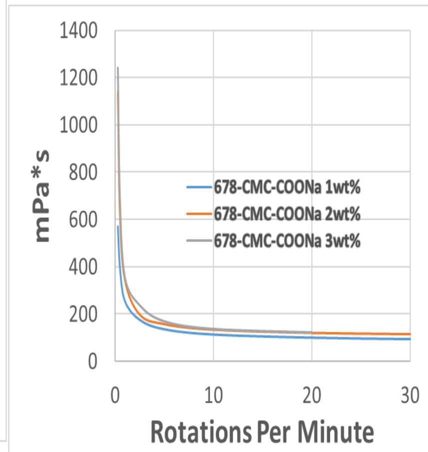



Figure 6
Viscosity of
678-CMC-COONa

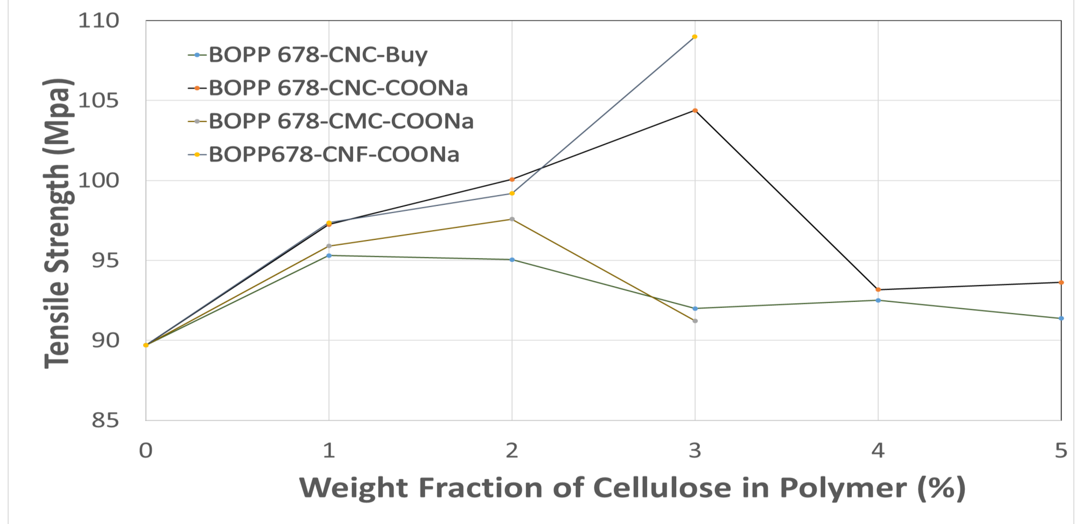



Figure 7
Tensile Strengths of BOPP Coated with Different Polymer Emulsions

The Ultimate Tensile Strength increases, then begins to drop as the weight percent of nanocellulose increases, this may be due to cellulose interfering with the continuity of the 678 acrylic of a lack of dispersion of the nanocellulose.

## Conclusions

- Viscosity increasing as a function of Nanocellulose weight percentage, may have difficulties in industrial coating settings.
- Ultimate Tensile Strength improvements for some weight fractions of nanocellulose when Polymers are coated on BOPP.
- Transparency of BOPP remains unaffected (for wavelengths in the visible spectrum) when it is coated.

## Future Research

The next steps of this research project would be to test the Gas Barrier Properties of the various acrylic polymer-nanocellulose emulsions once they are coated onto BOPP films. Analysis of the results from this testing can then be used to determine which Acrylic Polymer-Nanocellulose coating provides the most benefit of preventing Water Vapor, Oxygen, and Carbon Dioxide diffusion through the film.

## Acknowledgements

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